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APPLICATION

FOR

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TITLE: THERMOPHORETIC PROTECTION OF RETICLES

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THERMOPHORETIC PROTECTION OF RETICLES

Background

This invention relates generally to protecting reticles from particle contamination, for example during transportation.

Reticles are patterned devices that can be exposed to transfer a pattern on the reticle to a semiconductor structure. Through the use of reticles, patterns may be repeatedly transferred to semiconductor structures in an automated process. This greatly reduces the cost of forming integrated circuits.

Reticles are transported in a shipping container. Physical protection is provided by a shipping box. The reticle carrier that actually carries the reticle may be contained within an antistatic bag.

Conventional packaging is sufficient for optical reticles whose minimum printable particle size is roughly 30 microns. In such case, any particle smaller than 30 microns would not adversely affect the operation of the reticle.

However, with certain advanced lithography reticles, such as extreme ultraviolet (EUV) reticles, the technology is capable of resolving particles on the reticle that are much smaller than 30 microns. In these technologies, it is

desirable to maintain the reticle free of particles greater than 30 to 50 nanometers in size.

Current mechanical protection methods may be inadequate to prevent small particles from landing on the reticles. If particles landing on the reticle are large enough to adversely affect the transfer of the pattern from the reticle to the semiconductor structure, the reticle must be cleaned. Effective techniques for removing such small particles are largely unproven.

Thus, there is a need for better ways to remove particles from reticles.

Brief Description of the Drawings

Figure 1 is an enlarged cross-sectional view of one embodiment of the present invention.

Detailed Description

Referring to Figure 1, a shipping box 10 may enclose one or more packages 12. Each package 12 may, in one embodiment, be an antistatic bag that carries one or more reticle carriers 14. Each reticle carrier 14 may contain one or more reticles 16.

Also included within the box 10 is a self-contained thermophoretic source 18. By self-contained, it is intended to refer to the fact that a power supply is not needed. It is desirable to make the thermophoretic source 18 self-contained to facilitate transport of the box 10.

Thermophoresis is a process whereby particles are attracted to colder temperatures and repelled from warmer temperatures. Thus, particles inside the package 12 will be attracted to the thermophoretic source 18 and away from the reticle 16.

Thermophoresis is a non-continuum effect. The gas mean free path must be comparable or larger than the particle diameter for thermophoresis to occur. A temperature gradient causes a particle motion away from higher temperature and towards lower temperatures. Molecules in a higher temperature region contribute more momentum to particles than molecules in the lower temperature region.

Suitable thermophoresis sources include dry ice and Peltier or thermoelectric coolers. The thermophoretic source 18 generates a temperature gradient between the reticle 16 and the source 18 during transportation to provide thermophoretic protection of the reticle 16. In one embodiment, the thermophoretic source 18 in the form of dry ice may be contained within its own packaging so as to protect the remaining contents of the box 10 from the dry ice material.

Once the thermophoretic force drives particles to cooler surfaces, the particles may be bound to those surfaces by Van der Waal forces or by charge attraction. Cooling the reticle carrier 14 to a temperature below that

of the reticle 16 drives contaminating particles away from the reticle 16 and towards the cooler surfaces closer to the thermophoretic source 18.

Thus, in one embodiment, the thermophoretic source 18 may be positioned under the reticle carrier 14. In other embodiments, other positions for the thermophoretic source 18 may be utilized. For example, in some embodiments, the source 18 may be contained within the bag 12.

While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is: